Science IN THE *Third World*

ABDUS SALAM

THE FIRST EDINBURGH MEDAL ADDRESS

EDINBURGH INTERNATIONAL FESTIVAL OF SCIENCE & TECHNOLOGY

Abdus Salam

SCIENCE IN THE THIRD WORLD

The Edinburgh Medal Lecture

In this, the first Edinburgh Medal Lecture, the Nobel Prize winner and physicist, Abdus Salam, examines the status of science in the Third World and makes far-reaching suggestions for the improvement of science teaching and research in underdeveloped countries.

Abdus Salam is Professor of Theoretical Physics, Imperial College, University of London, a Nobel Prize winner, and Director of the International Centre for Theoretical Physics in Trieste.

EDINBURGH UNIVERSITY PRESS
22 George Square, Edinburgh
ISBN 0 7486 0144 9

Science in the Third World

ABDUS SALAM

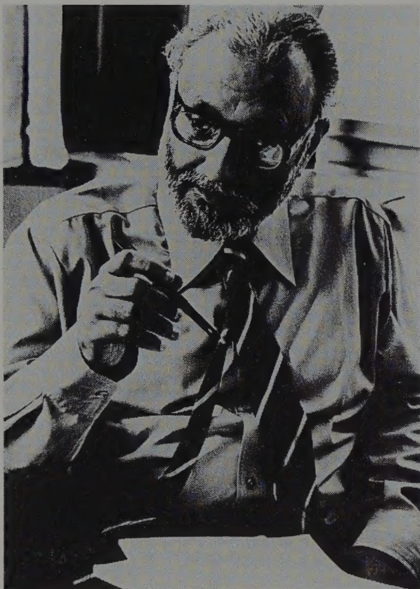
Science IN THE *Third World*

ABDUS SALAM

THE FIRST
EDINBURGH MEDAL
ADDRESS

Set in Berthold Bell by
Hislop & Day Ltd., Edinburgh
and printed in Great Britain by
Alna Press, Broxburn, West Lothian

ISBN 0 7486 0144 9



PROFESSOR ABDUS SALAM

Introduction

My Lords, ladies and gentlemen, it is with great pleasure that I welcome here tonight, on behalf of the City of Edinburgh, Professor Salam to receive the first ever Edinburgh Medal.

But before I present the medal I should like to say a little about the festival – or, to give it its full title, The Edinburgh International Festival of Science and Technology – and which, like everyone else, I will call the Science Festival.

Science and technology plays a central role in our society. Its rapid development over the past 200 years has made possible and helped to form the world we live in now and – as Rear-Admiral Shepherd told us earlier in the week – the ability to leave the world too.

But, although Dr. Becklake of the National Science Museum argued, also earlier this week, that the earth was only the cradle of humanity from which like any baby we were destined to leave. I suspect for all of us here and for many generations to come the earth will be our home.

And on this planet we face a multitude of problems.

There are the headline issues of the moment – famine in Sudan, the Exxon Valdez oil pollution in Alaska, the destruction of the Amazonian forest, the depletion of the ozone layer – all these issues being debated and discussed in this year's festival.

But there are also continuing issues that do not often make the headlines – the scourge of diseases that, conquered in some parts of the

world, continue to rage elsewhere, of poverty and malnourishment that dog millions of the inhabitants of our world in every day of their lives and of the slow but steady build-up of poisons in the eco-system.

Not that I wish to be gloomy because I believe that these challenges can and shall be met. The question for all of us is how do we meet these challenges.

The resolution of these and many other issues are in our hands. In applying our skill and knowledge and in co-operating together in debate to identify the solutions and the way forward we can create a world that matches our aspirations.

In that task the development and use of science and technology will be crucial.

There are, I believe, essentially only two popular images of science, one is that it is danger and a threat and the other that it is a magic wand that applied to any problem will solve it.

Of course neither is true but what is common to both views is that science is seen as external to the rest of our daily society.

We hope that as the Science Festival develops over the next few years into a major international event that it and our city can play a major rôle in assisting those debates and in overcoming the view that science for most of us is something that happens outwith our understanding and control.

It is vital too that these debates are ones which are not only for scientists and technologists – they are for all of us. The continuing development of science and the rapid rate of the applications of new

technologies grant us the power to solve some of the problems I mentioned earlier but they also raise political and moral questions that have to be understood and judged by all of society.

There are many divisions in our world, of nationality, creed, race, and class – and particularly in the scientific field between the expert and the layperson.

I hope that the science festival will become an international venue in which those divisions are broken down or transcended. That we learn from each other, and in gaining an understanding of how the form and nature of science both arises out of our society and also acts on it, the festival and our city will make a worthwhile contribution to a better world.

Although the world is a very different place to what it was 200 years ago I believe that the same ferment and excitement of scientific endeavour that flowered in the enlightenment in Edinburgh can arise out of this festival and again provide a service to our world.

So this festival is not only a recognition of the challenges that face humanity but also a challenge to the scientific and technological community world-wide to meet and debate, both between themselves, but most importantly with the public, on the nature and rôle of science and technology in our society.

It is also of course a challenge to our city to rise to meet that rôle. It is a challenge I believe we can confidently meet. Along with our justly renowned international arts festival we can say that this is a city in which the two cultures of science and art meet and integrate again as they once did during the enlightenment.

It is against that overall endeavour that the City Council has established the Edinburgh Medal and Lecture.

Its objective is to honour an individual but not just to rest on past glories but to offer that person a platform within the international festival to address the world under the general theme of science and society.

Although as a city we are honouring Professor Salam I believe he also honours us in his acceptance of this the first medal and the delivery of his lecture.

There are few people, I believe, who in their own person represent two of the main aspects of the festival as he does.

In his development of our understanding of the basic forces of the universe he has pushed forward the bounds of our knowledge and secondly, in his strenuous work to ensure that the benefits of that knowledge are available to all in our world, particularly through his establishment of the International Centre for Theoretical Physics in Trieste.

In these two matters the striving for knowlege and the dissemination and discussion of that knowledge to all he has made a contribution to humanity that this city honours.

Eleanor McLaughlin
Lord Provost

The Lecture

I am deeply honoured by the award of the first Edinburgh Medal and the Prize. The Prize will go towards funding the Talent Fund for developing countries which I had set up from the Nobel Prize. The Holy Prophet of Islam taught us to "thank men and women whenever they do good for you" – for "whosoever does not thank people, does not thank Allah." In keeping with this teaching I express my gratitude to you for kindly awarding me the Edinburgh Medal and Prize.

I came to the UK in October 1946 and my first port of call outside of Cambridge in December 1946 was Edinburgh where I was the guest of Professor Henry Jack, who was taking the maths tripos with me. Henry Jack was the biggest man I had ever seen in my life till that time. He was equally big and gracious in his hospitality. I fell in love with Edinburgh right away. Its fresh breezes seemed to course through the city – reminding me of the fresh breezes which coursed through my native town of Jhang.

Then Professor N. Kemmer, at Cambridge my supervisor for Ph.D., moved to Edinburgh leaving an empty place in Cambridge

which I was invited to fill in 1954. Kemmer had been an assistant of Professor Pauli and is very proud of it. Thus Edinburgh became a port of call for me once again. I remember the visit of Professor W. Pauli during 1957, when he was entertained for lunch by the Department of Physics. Pauli was a bit sleepy after lunch with the hospitality and the whisky which had been showered upon him, but there was no getting away from Professor Kemmer, who asked his and my ex-student J. C. Polkinghorne to perform in front of Pauli and tell him what he had been doing on dispersion relations. Pauli had the status of an oracle in our subject. His word was law. But, just after a big Scottish lunch, it was a bit of a tall order for him to concentrate. So when Professor Kemmer very sweetly, at the conclusion of Polkinghorne's presentation, asked Pauli what he thought about the subject, Pauli opened his eyes slowly and deliberately and said: "I pay no attention to dispersion-relations. I leave them to my present assistant." And that was all that one could get out of Pauli – the oracle – *at that moment.*

The next big occasion when Edinburgh was very much in my thoughts was during 1963-64 when I learned about the Higgs mechanism proposed by Professor Higgs. I learned it from Professor T. Kibble, who is also an Edinburgh graduate (Kibble is Head of the Department at Imperial College). Kibble taught me about the Higgs mechanism which both Weinberg and I used to bring about spontaneous symmetry breaking in the unified electroweak theory, which got us the Nobel Prize.

This unification was couched in the same mould as the unification which was wrought by James Clerk Maxwell, a

Scotsman and one of the greatest physicists the world has ever seen, concerning the relation of electromagnetism with radiation. Maxwell had shown that when a charged particle is accelerated, it radiates. He had found the *speed* of radiation to be equal to the *ratio* of electromagnetic to electrostatic *charge*. From this one number, which was measured carefully, and which was found to be nearly the same as the velocity of light, he went on to assert that electromagnetism and radiation are united. Maxwell died very young and did not live to see the great ideas being carried out in the laboratory to show that accelerating charges do produce radiation with the same velocity as that of light. But this unification remains one of the greatest landmarks in the whole of physics.

The Higgs Particle now forms the subject of even popular accounts of what to look for in the new generation of Particle Physics accelerators.

A humorous excerpt from an article by Peter Simple entitled "Quark Vader", which appeared in the London *Daily Telegraph* on 27 April 1988, was read out by D. H. Perkins at the 1988 Munich Conference:

"American scientists are planning to erect the largest man-made structure in the world apart from the Great Wall of China ... the scientists hope that this (the SSC) will prove one way or another their theory that almost everything that happens in the universe can be explained in terms of a cosmic struggle between two armies of particles, the quarks and the leptons. As yet, the theory has remained unproven because, as it is reported, 'for the sake of

symmetry the physicists have yet to find the sixth quark and, most important, have had to introduce another particle, the Higgs particle, named after Peter Higgs of Edinburgh University. So, is the last riddle of the Universe about to be solved? Well, not entirely, because it turns out that 'the SSC will not be able to hunt directly for the Higgs particle' since this 'decays almost immediately' and furthermore some physicists 'like Chris Quigg hope they do not find it'. Just what is going on here? Who are the goodies and baddies in this story? Is Quigg the leader of the Leptons? Is Higgs himself the mysterious 'Sixth Quark', shadowy ruler of the universe? Will Quigg's leptons manage to overthrow Higg's evil empire before it is too late?"

The next occasion was in 1971 when Edinburgh University, at the instigation of Professor Kemmer, awarded me my first Honorary D.Sc. degree in very select company.

* * *

My thesis in speaking to a forum like this one is that the situation in the developing world is so bleak that without active involvement of the international scientific community it will not change. My thesis is that indigenous science in the developing world is weak, but that it should expect and demand, as it were of right, fullest support from science abroad. We scientists pride ourselves as being the last of the idealists, our motives are not politically suspect, we fortunately possess a fund of goodwill through the work of the institutions which include private foundations, as well as the scientific agencies of the United Nations family.

The involvement of the world scientific community and the help it can give to the weak scientific communities in the developing countries can take many different forms. I shall describe only some of the possible ways. In particular I shall concentrate on some of the institutional means the world community may possibly use. But this is in no way meant to minimise the importance of the other means which I shall not talk about. The crucial point is a realisation on the part of the world scientific community that here is a sphere where they can directly help and they are expected to help.

But before we can make an assessment of what is needed today I feel it is important to get an idea of the past, particularly of why it is that the developing world, and particularly those parts of it with glorious traditions of a scientific past, have been so tardy in achieving the modern scientific transformation. Since personally I am most familiar with my own, the Islamic civilisation, I shall select my illustrations from its history.

Almost exactly 1,200 years ago, Abdullah Al Mansur, the second Abbasid Caliph, celebrated the founding of his new capital, Baghdad, by inaugurating an international scientific conference. To this conference were invited Greek, Nestorian, Byzantine, Jewish, Chinese, as well as Hindu scholars. From this conference – the first international scientific conference in an Arab country – dates the systematic renaissance of science associated with Islam. The theme of the conference was observational astronomy. Al Mansur was interested in more accurate astronomical tables than were available then. He wanted, and he ordered at the conference, a better determination of the circumference of the earth. No one realised it

then, but there was read at the conference a paper destined to change the whole course of mathematical thought. This was a paper read by the Hindu astronomer, Kankah, on Hindu numerals, then unknown to anyone outside of India. Kankah had come to the conference to present to it copies of various Siddhantas – the Hindu manuals of astronomy.

Al Mansur's conference succeeded beyond all expectations. It laid the foundations of astronomical and mathematical studies in Islam; from this conference grew the idea of the founding of one of the world's first *international* Academies for Scientific Research, the Bayt-ul-hikma. But even on the more practical, more pragmatic plane, from this conference date the architectural and engineering studies of Naubakht and Mashallah, both of whom attended its sessions and who were later responsible for some of the major monuments of Baghdad. From this conference dates the craft of instrument making in Baghdad, whose specimens still survive in the master-works of Isa Asturlabi.

The fact that there was collected at Baghdad this concourse of scholars, forming an international gathering, was not purely accidental. The Arabs were building on the heritage of Greek science, the custodians of which at that epoch of history were the Nestorian Christians who, bitterly persecuted by the Byzantines, had emigrated to Mesopotamia, and later to south-west Persia, from the sixth century onwards. They had made a home at Gondisapur, not far from Baghdad. They possessed, in Syriac, translations of works of Plato, Aristotle, Euclid, Archimedes and Hippocrates. The existence of this Nestorian Hellenistic centre of learning,

Gondisapur, was Allah's gift to a new civilisation, then bursting with youthful zest and fired with the Prophet's injunction to value science and learning above everything else. On this foundation, carefully nurtured, the Caliphs in Baghdad built, importing also Chinese and Indian scholars.

The next 450 years saw the brilliant flowering of Islamic sciences and learning, both in Eastern Islam as well as in the West, in Spain. What during this period was the attitude of Western Europe towards this outpouring of knowledge? In Charles Singer's words: "This attitude was the same which the Oriental now has towards the West. The Orient recognises that with the West are science and learning, power and organisation and business enterprise, but the admitted superiority of the West does not extend to his sphere of religion. He gladly accepts Western standards of economics, technology, science and medicine, but repudiates and perhaps despises the religion, philosophy and much of the social outlook of the West. In the Europe of the tenth and eleventh centuries it was exactly the opposite. The West knew full well that Islam held the learning and science of antiquity. Muslim proficiency in arms and administration had been sufficiently proved." But with this longing for the intellectual treasures of the East, there was fear that Christian values and Christian culture would be deletereously affected. Thus no attempt was made to borrow or to make contact. An eloquent expression to these fears was given in a lament by Alvaro of Cordova writing in the ninth century. "Many of my co-religionists read the poetry and tales of the Arabs, study the writings of their scientists and philosophers, but where are those

among us who can read the Latin commentaries on the Holy Scriptures? Among thousands of us there is hardly one who can write a passable Latin letter to a friend, but innumerable are those who can express themselves in Arabic and compose poetry in that language with greater art than the Arabs themselves."

This feeling of repugnance on the part of the West lasted some three to four hundred years. It then began to change. It is not commonly recognised how important the last half of the eleventh and the first part of the twelfth century are for the development of the European science and European civilisation. For some reason there arose in Italy, France, Scandinavia and Britain a number of men who were willing to brave the disapprobation of the Church and its odium in order to make available to the West the learning of the East and the international intellectual treasures of humanity garnered and improved upon by the Arabs from Greece, India and China.

One of the most important among these men was an impoverished Scotsman who left his native glens to travel south to Toledo in Spain, some seven and fifty years ago. For my second historical illustration I shall consider the life and work of this Scotsman. His name was Michael, his goal to live and work at the Arab universities of Toledo and Cordova. Michael reached Toledo in 1217. Toledo was an Arab town but not then in Arab hands. It had been captured by the Spanish Christians 100 years before, but the tradition of Arabic learning, Arab teachers and language remained intact. One may note the parallel with the international centre of Gondisapur of the Nestorians 500 years before, which had been

captured by Islam but had retained its Christian identity. In Toledo, Michael the Scot formed the ambitious project of introducing Aristotle to Latin Europe, translating not from the original Greek, which he did not know, but from the Arabic translation of Aristotle then taught in Spain. Exactly 100 years before, Adelard of Bath, an Englishman, had done a like service for geometry by translating Euclid into Latin, not from the original Greek, but also from an annotated Arabic translation.

Toledo's school, representing as it did the finest synthesis of Arabic, Greek, Latin and Hebrew scholarship, was one of the most memorable of international essays into scientific collaboration. To Toledo and Cordova came scholars, not only from the rich countries of the East – like Palestine and Egypt – but also from developing lands of the West – like Scotland. Then, as now, there were obstacles to this international scientific concourse. First, there was the political division of the world. In 1217 the wounds of the Third Crusade, fought barely 30 years before, were still not healed. And then there was the economic and intellectual disparity between different parts of the world. Men like Michael the Scot and his contemporary in Toledo, Alfred the Englishman, were singularities; they did not represent any flourising schools of research in their own countries. With all the best will in the world, their teachers at Toledo doubted the wisdom and value of training them for advanced scientific research. At least one of his masters, despairing of his lack of grounding in science, counselled young Michael to go back to the clipping of sheep and weaving of woollen cloth.

Added to Michael's lack of background training, there was the

disapprobation of the Church I have spoken about. Michael's countryman, Sir Walter Scott, in his "Lay of the Last Minstrel" has given expression to this disapprobation. The minstrel in Scott's poem tells us how Michael was accused of wizardry and other deadly sins:

> In those far climes it was my lot
> To meet the wondrous Michael Scot;
> A wizard of such dreaded fame,
> That when in Salamanca's cave
> He lifted his magic wand to wave,
> The bells would ring in Notre Dame!

The lay goes on ...

> When Michael lay on his dying bed
> His conscience was awakened.
> He bethought him of his sinful deed
> He gave me a sign to go with speed.

But nothing could save Michael's soul. Dante found Michael in agony in one of the lowest circles of the Inferno – all for the deadly crime of learning Arabic and teaching Europe the Arab sciences of mathematics, biology and philosophy.

Another 200 years were to pass. During these 200 years, the devastation caused by the Mongols and Tamerlane destroyed all tradition of scientific enquiry in the lands of Islam. The tables were now completely turned; it was the Muslim scholar who had turned inward; inward towards the spiritual security afforded by his past

cultural tradition; shunning all contact with newer thought which came now from the Western lands. One of the last of the great scholars in Islam, Ibn-Khaldun, whom Toynbee describes as a man who conceived and formulated a philosophy of history which remains the greatest work of its kind that has ever been created by any mind at any time at any place – even a man of such calibre, writing 200 years after Michael the Scot, in 1400 A.D., about sciences in Christian lands expresses himself thus: "We have heard of late that in the land of the Franks and on the northern shores of the Mediterranean there is a great cultivation of philosophical sciences. They are said to be studied there again and to be taught in numerous classes. Existing systematic expositions of them are said to be comprehensive, the people who know them numerous and the students of them very many. Allah knows better what exists there but it is clear that the problems of physics are of no importance for us in our religious affairs. Therefore we must leave them alone." Ibn-Khaldun displays no curiosity, no wistfulness; just apathy bordering on hostility.

How can this situation be changed? I said earlier that a crucial initial role was played in building up science in Islamic and Christian civilisations by the essentially alien international centres of Gondisapur and Toledo representing traditions of living science in the midst of their own societies. I believe that something similar to these centres will have to be created in the developing world before it begins to enter into the spirit of a true scientific revolution. *Nothing can give that instinct of what is credible and what is not, that fine sense of the scientifically genuine and the scientifically deceptive, as the*

direct experience of living science – living in your own conditions and environment and flourishing within your own cultural tradition. The problem which concerns us today is this: Can we caputure or create the Gondisapurs and Toledos of today by our own efforts unaided within our countries? By and large, the answers appear to be: No! The reasons are simple. Science feeds on science. Men of science wish to work where other such men are and where they obtain facilities. We in the developing world cannot or will not afford these facilities, either through actual poverty, or through a poverty of spirit; far from attracting the foreign great men, we are likely to lose our own, retarding thereby still further the scientific transformation of our societies.

I have spoken of the modern parallels of Gondisapur and Toledo, centres of scientific excellence set up in developing countries in conjunction with local universities or outside them, but backed strongly by the international science community. One of the important problems which arises in connection with such centres is: how should they be sponsored?

In September 1960 I had the privilege for the first time of attending the General Conference of the IAEA as a delegate from Pakistan. It seemed to me a good thing to try to make at least a beginning toward an international United Nations university, benefiting university scientists both from developing as well as developed countries, by proposing to set up a post-graduate Centre for Theoretical Physics under the IAEA auspices. With the co-sponsorship of the governments of Afghanistan, the Federal Republic of Germany, Iran, Japan, the Philippines, Portugal,

Thailand and Turkey, we introduced a resolution on behalf of the Pakistan Government, suggesting that an international centre for research in theoretical physics should be set up under the auspices of the IAEA. In consonance with the standard UN practice, the resolution started with a preamble which stressed the unique virtues of theoretical physics for peace, prosperity and health of mankind.

The proposal met opposition from the USA, USSR, UK, France, Germany, Holland, Belgium, Canada and Australia. The Australian delegate was probably the most vociferous. He said, "When Professor Salam talks of Theoretical Physics, let us remember that Theoretical Physics is the Rolls Royce of Science. What the developing countries need are donkey carts".

Of the list of nations first sponsoring the idea, most were the less-privileged countries. It was clear that the setting up of such a centre was of interest to these nations, for the hope was that it might help in resolving one of the frustrating problems which their active university physicists face – the problem of isolation. Such men could come frequently to a centre of this type, not to stay permanently but to renew their contracts and then to go back refreshed after a period of concentrated research. This would not solve the problem of heavy teaching duties in their own countries, it would be no substitute for building up centres of excellence in their own countries, but it would certainly end one aspect of their disabilities – isolation from newer ideas.

Right from the outset the idea met with enthusiastic support

from the IAEA's directorate, particularly from its distinguished Director General, Dr. Sigvard Eklund, as well as from the physics community. Two of our most ardent sponsors were Niels Bohr and Robert Oppenheimer.

When in 1961 I was President of the Pakistan Association for the Advancement of Science, I quoted in my Presidential Speech in Dacca an article by Dr. J. M. A. Lenihan, entitled "What is wrong with Scotland?" After painting a rather gloomy picture of consistent economic decline, Dr. Lenihan councluded that this decline stems entirely from lack of trained technologists. To the objection that if there is no industry in Scotland there is no need for technical colleges, Dr. Lenihan countered by remarking "The scientist, the technologist and the technician are, in the main, products of the educational system, not of the industrial system in which they hope to work. A coherent demand for technical education facilities will not rise from an assortment of industries but the existence of technically trained people will facilitate the growth of new industries."

There is one other passage from Dr. Lenihan's address which I would like to quote. After listing a number of difficulties which face the Scottish economy he goes on to say "many of the difficulties that have been mentioned are the natural consequences of living in a country" – that is Scotland – "where science is not taken seriously enough. How else can we describe a country which, fighting for economic survival in a world dominated by technology, allows the basic sciences of physics and chemistry only the status of half subjects in the school curriculum."

An index of the sub-criticial size of Science and Technology is the numbers of those engaged actively in this activity in the Third World. The UNESCO figures in Table III paint a different picture for the South and the North. In the North an order of several thousand inhabitants per million[1] are engaged – in Research and Development (and the numbers keep rising year after year) – while those similarly engaged in the South seldom exceed more than a few hundred. There is a factor of at least one or two orders of magnitude (tens of hundreds) between the respective numbers. The Chinese figures in this context are revealing. According to Professor Lu Jiaxi, former President of the Chinese Academy of Sciences – speaking on Chinese Science at the Second General Conference of the Third World Academy of Sciences in Beijing in September 1987 – the Chinese had fewer than 500 researchers in 1949 altogether – less than one per million of population. The situation in most developing countries today is similar to that in China in 1949. (There are now 300,000 researchers in China and the country is approaching international norms, with a factor of 600 increase in 40 years.)

Regarding the numbers engaged in Science and Technology promotion, Developmental adaptation and modification, plus extension and utilisation, the situation is the same.

One of the revealing indices of the size of Third World Science and Technology is the funding which the South provides for Research, Development and Utilisation of Science and Technology.[2] (This is correlated with the smaller numbers engaged on Science and Technology). To appreciate this, one has only to

1 It has been estimated that the UK would need 800 doctoral standard physicists every year for the next five years. Compare these numbers with those of Pakistan's 46 Ph.Ds for all of its 19 universities (with twice the population of the UK).

2 According to an empirical law discovered by the late Professor Jolla Price of Yale University, with few exceptions, a country's output of scientific research is directly proportional to its spending on Science and is correlated with its GNP.

look at Tables I, II and III which give the Defence, Education, Health and Science Expenditures as percentages of GNP, both in the South and the North.

The point about the Tables is the following: Both the industrialised and the developing countries spend 5.6% of their respective GNPs on defence. The educational expenditures are also similar – 5.1% for the industrialised versus 3.7% for the developing countries. For health it is 4.8% for the industrialised versus 1.4% for the developing countries – admittedly, a difference, but not as striking as for Science and Technology. The figures for Science and Technology differ from each other by nearly an order of magnitude.

The industrialised countries spend 2-2.5% of their GNPs on Research, Development and Modification, Adaptation plus the

Table 1
Defence, Education and Health Expenditures in US dollars (1984) (as % of GNP)

	Population (x 1,000)	GNP (million US$)	GNP Capita (US$)	Defence (%)	Education (%)	Health (%)
Industrialised countries	1,125,033	11,019,363	9,795	5.6	5.1	4.8
Developing countries	3,651,353	2,697,982	739	5.6	3.7	1.4
Africa*	517,588	356,774	651	4.4	3.8	1.1
Middle East**	100,901	314,518	3,117	18.7	6.2	2.6
South Asia	992,628	266,330	268	3.5	2.8	0.8
Far East***	1,513,771	726,496	480	5.9	3.2	0.9
Latin America and Caribbean	394,718	752,688	1,907	1.6	3.7	1.3

Based on *World Military and Social Expenditures*, by Ruth Leger Sivard, World Priorities, Inc., Washington D.C., 1987.

* Less South Africa ** Less Israel *** Less Japan

Table II

Industrialised Countries' Expenditure on Science and Technology

Country	Population	GNP per capita (US$) 1984	Public Expenditures in Education (% of GNP)	Scientists/ Engineers in R & D (per million inhabitants)	Expenditure on R & D* (% of GNP)
France	55.17 (1985)	9,540	5.8 (1983)	4,500 (1988)	2.25 (1980)
Federal Republic of Germany	61.02 (1985)	10,940	4.6 (1984)	3,000 (1988)	2.54 (1984)
Japan	120.75 (1985)	11,300	5.6 (1984)	6,500 (1988)	2.65 (1984)
Netherlands	14.48 (1985)	9,290	6.9 (1984)	4,500 (1988)	1.97 (1984)
U.K.	56.49 (1984)	8,460	5.2 (1984)	3,200 (1988)	2.3 (1984)
U.S.A.	1.293.30 (1985)	16,690		6,500 (1988)	2.69 (1984)

* Based on UNESCO statistics (1987). (These figures may include: application, diffusion and commercialisation and venture capital for technology provided by governments as well as by private industry, plus defence R&D).

Utilisation of Science and Technology: versus less than 0.3% (on UNESCO's estimates, Table III) for most developing countries. (There are some few exceptions - the most notable ones being Argentina, Brazil, Cuba, India, Mexico and South Korea, which spend more than 0.5% on Science and Technology).[3] Even though one may argue that spending on Science and Technology is only a necessary condition for the developmental aspects of science and Technology and not a sufficient one (on account of other motivational (for example, cultural) factors which may be just as important), it remains a fact that the industrialised countries are expending (in GNP terms) on the average seven to nine times more every year on Science and Technology than the Third World. We in the Third World are just not serious about Science and Technology. The profession of Science and Science-based

3 *We were heartened to hear from our colleagues on the South Commission that from 1989, during the next five years, Venezuela's expenditures on Science and Technology may go up to 2% of GNP from its present 0.4%, with state action for the utilisation of scientific and technological research. At his inauguration ceremony on 2 February 1989, President Carlos Andres Perez promised that after reorganising the Federal Government – for which he appointed a special minister – he would make Science and Technology a top state priority. (Special United Nations Service Bulletin, No. 2094 of 6 February 1989). We were told that the Philippines' expenditures may likewise go up from 0.2% to 1.5% and Brazil's, from its present 0.6% to 2% of GNP by 1990. Cuba, we were told, is already spending 0.9% of its GNP on Science and Technology. Iran is expected to raise its spending on Science and Technology from its present 0.5% to 1% of GNP with immediate effect and to 2% later. South Korea is spending on Science and Technology 2% of GNP. This will rise to 3% by 1992.*

Table III

Estimated Expenditure for Research and Development in 1980 as Percentage of G.N.P.

(Selected Countries)

ASIA		LATIN AMERICA AND CARIBBEAN		AFRICA	
Bangladesh	0.2	Argentina	0.5	Algeria	0.3
India	0.9	Brazil	0.6	Egypt	0.2
Indonesia	0.3	Chile	0.4	Nigeria	0.3
Iran	0.5 *	Cuba	0.7		
Iraq	0.1 *	Mexico	0.6		
Pakistan	0.17	Peru	0.2		
Philippines	0.2	Venezuela	0.4		
Singapore	0.5				
Sri Lanka	0.2				

(From UNESCO Statistical Yearbook 1987)

* 1975 figures.

Technology is hardly a respectable, hardly a valid, profession in the South.[4]

If this is a major problem which the South is facing, what can we do about this? I have made some suggestions about this in my report to the South Commission. These are as follows:

(i) 10% of the Aid Funds to be earmarked for Science and Technology.[5] The linking of the aid for Science and Technology with the total bilateral aid from the North is an important political modality. It should come to be established (principally through the type of requests made by the South, as well as favourable reception to such requests by the North), that 10 per cent of the aid given by every developed country is to be spent to enhance Science and Technology in the Third World.

4 In the British Colonial Empire, Britain did not leave behind the concept of a Scientific Civil Service which, incidentally, had been part of the United Kingdom's own administrative structure.

5 This would amount to $3.5 billion. $3.5 billion (in foreign currencies) for Southern Science and Technology would make up (together with the domestic $14.5 billion, argued for earlier) a total of $18 billion. This would constitute some 10% of the world's spending on Science and High Technology and, even though small, this could, without doubt, transform the South.

(ii) Birthright of Southern Scientific Communities: Free Access to Scientific Literature. It should be considered as part of a birthright of scientific communities in a developing country that the country should have at least one complete Central Science Library containing all Science journals and all scientific books. Arrangements (by the Aid Organisations or the World Bank) should be made with publishers in the North that such books and journals are made available at a fraction of their present price – at least one copy for each country – and sent to a designated Central Library in at least fifty of the developing countries, which can make use of this literature right away.

(iii) United Nations Agencies and International Centres for Science. In multilateral co-operation, the United Nations agencies, including the United Nations University, should have a prominent rôle in building up scientific infrastructure in their areas of competence. Developing countries need international research institutions on the applied side like the Wheat and Rice Research Institutes in Mexico and the Philippines and the International Centre for Insect Physiology and Ecology in Kenya. There is also the experience on the basics side, of UNESCO and IAEA in relation to the International Centre for Theoretical Physics, Trieste (with visits of 4000 physicists last year – 2500 of them from developing countries and 1500 from the industrialised countries), or, of UNIDO for the International Centre for Biotechnology and Genetic Engineering, at Trieste and Delhi, on the applied side. These centres are run by the scientists for the scientists. The South should, at the least, utilise those trained at these centres and urge

other United Nations Organisations to set up international centres in disciplines relevant to their competence.

In this context, there is the proposal to create in Trieste an International Centre for Science which shall have five components: (1) the existing International Centre for Theoretical Physics (which I have discussed already); (2) the existing International Centre for Genetic Engineering and Biotechnology; (3) a new International Centre for High Technology and New Materials; (4) a new International Centre for Chemistry, Pure and Applied; and, finally, (5) a new International Centre for Earth Sciences (for research in and for imparting knowledge of the recent advances in geology, prospecting, soils, as well as for the environmental aspects of Earth Sciences, including man-made global change). The International Centre for Science will be created with United Nations sponsorship by the Italian Government.

I have mentioned the International Centre for Theoretical Physics in Trieste, which was created through the voting of the poor countries, with an initial total budget of not more than $350,000. The centre has certainly flourished during the intervening 25 years. Our budget is now $16.6 million.

We have so far been able to concern ourselves mainly with Physics, both Applied as well as Pure, in all its disciplines, which include Fundamental Physics, High Energy Physics and Relativity, Physics of Condensed Matter and Physics of Energy, Environmental Physics, Physics of the Living State and Applied Physics. At present of the order of 40 colleges, each lasting one

month or over, are conducted at the Centre, which provide training at the highest possible level, in addition to the conferences and topical meetings. The Centre operates five modalities to help those from developing countries. There is the Programme for Training and Research in Italian Laboratories; there is the External Activities Programme for which we provide $1.8 million for activities outside Trieste; there is the Book and Scientific Equipment Donation Programme; there are the Associateship Membership and the Federation Schemes. Associate Members are scientists working in developing countries who come here for a period of six years during which they are entitled to three visits, each of which should not exceed three months but should last more than six weeks. There are at present 319 scientists from 62 nations who are Associates of the Centre. In addition, there is the Federation Scheme, through which we allocate a number of days to about 334 institutions around the world which then receive physicists from these institutions whose selection is done by the institution itself.

As an anti-brain drain device, the Associateship Scheme has worked superbly. Out of 18,000 visits which we have had from developing countries physicists, not one has gone away from his country through the operation of the Trieste Centre.

I have recited these achievements at Trieste with a very special purpose. The special purpose is to suggest that new Centres for Science should be created, particularly at Edinburgh and in Scotland with a special mandate to help the countries of the South and also, of course, to help local Scottish industry in extending its hospitality and bettering itself. This is something which has

happened in Trieste where a number of new endeavours have opened up because we happened to be there. For example, the Synchrotron Radiation Laboratory has been set up and a Research Area has been constructed on the basis of what we have been doing. There is also an International School for Advanced Studies of the Italian Government next to the Centre. I would like to suggest an institution which may be created in Scotland to be very closely connected with the one in Trieste. In this context, there is the proposal to create in Trieste an International Centre for Science which I mentioned earler. I happened to see Minister Andreotti, the Italian Minister of Foreign Affairs, on 5 February 1988 when I spoke to him of the need for these ideas and he was kind enough to charge us with the tasks of drawing up the plans for such centres. We did that and I saw him again on 7 March this year. He was, of course, very pleased to see the results of our work and has promised $10 million for each one of the three centres to be constructed in Trieste. I would like the Edinburgh centre to be even more ambitious and start with £10 million rather than $10 million. It can take care of high technology for which there is need of hundreds of institutions and not just the two which we are talking about.

APPENDIX 1

THE INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

A. M. Hamende

1. On behalf of the Government of Pakistan, Professor Abdus Salam submitted a proposal at the 1960 General Conference of the International Atomic Energy Agency (IAEA) to create a Centre for Theoretical Physics. The proposal met with enthusiasm on the part of the developing country delegations but with a more tepid attitude from the industrialised countries. The first real battle for the creation of the Centre occurred at the 1962 IAEA General Conference. The Australian delegate said, "Theoretical physics is the Rolls Royce of Sciences. Developing countries do not need Rolls Royces, they only need donkey carts!" Nevertheless, after other vicissitudes, the IAEA decided to create the Centre in Trieste in 1964 with an annual budget of US$55,000. Fortunately, the Government of Italy provided US$ 300,000 per year for the operation of the Centre. The City of Trieste and the Regione Friuli-Venezia Giulia provided a provisional building for four years, while a US$1,200,000-worth new building was being erected in the vicinity of the Castle of Miramare, five miles from the centre of the city. Other offers to host the Centre had been received from Austria, Denmark, Pakistan and Turkey, but the Italian offer was by far the most generous. Until 1970, when it joined IAEA as a full partner in the operation of the Centre, UNESCO had provided fellowships tenable in Trieste.

2. The programmes of the Centre encompass a large spectrum of scientific disciplines from the most sophisticated subjects, like the ultimate structure of elementary particles down to more practical domains like remote sensing or telematics. More precisely, the Centre deals with Fundamental Physics, Physics of Condensed Matter, Mathematics, Physics and Energy, Physics and Environment, Applied Physics and Physics Teaching.

3. The activities of the ICTP include several components: (a) research; (b) high-level training courses; (c) training in Italian laboratories; (d) external activities; (e) book and scientific equipment donation programme; and (f) training laboratories. The Centre also runs a weekly programme of lectures on Science and Development.

3.1 Research is carried out throughout the year in fundamental physics, physics of condensed matter, plasma physics and mathematics. A small permanent international staff, full professors of the Department of Theoretical Physics of the University of Trieste and of the International School for Advanced Studies (ISAS) and senior visiting scientists provide guidance to younger and less experienced physicists and mathematicians invited for periods ranging from one to twelve months and coming from all over the world. The ICTP also welcomes postdoctoral fellows for open or two years.

3.2 High-level training courses and workshops, conferences and topical meetings. Soon after the creation of the ICTP, it was realised that the scientists of developing countries needed additional experience and training to keep their research up to date if they were to be competitive on the international scene. With this purpose in mind, high-level courses were instituted in condensed matter physics, nuclear physics, plasma physics and

in mathematics during the first five years of existence of the ICTP. Many other subjects were added later. High-level training courses have a duration of three to ten weeks and are attended by 70–90 participants mostly from developing countries. They include exercises with computers or scientific equipment whenever necessary.

Workshops, as a rule, differ from the courses in that they are more focused on research, thereby leaving more time for discussion and collaboration. In principle, they cater to already experienced scientists. In addition, the ICTP organises conferences and topical meetings on advanced subjects.

Between thirty-five and forty-five courses, workshops, conferences and other meetings are now held each year.

3.3 The programme for training and research in Italian laboratories enables experimentalists from developing countries to participate in research at laboratories belonging to universities or governmental and industrial institutions. Grants are given for periods ranging from a few months to a year, depending on the conditions set by the host laboratory. Some 300 laboratories are able to host ICTP trainees. Some 70–80 trainees are placed each year.

3.4 The External Activities Programme was created in 1985 and became operational in 1986. In a first phase, the ICTP provided financial as well as intellectual assistance in five programmes, i.e. training activities, workshops, conferences, physics and mathematics teaching and visiting scholars, who help research groups in developing countries wishing to embark on a new major project or introduce a new line of research; 256 programmes have been financially supported so far.

In a second phase, the ICTP will give special attention to the formation of scientific networks and the establishment of affiliated centres.

3.5 The Book and Scientific Equipment Donation Programme. This programme provides universities in developing countries with books, journals and proceedings. These publications are normally donated to the ICTP by individuals, libraries, publishing companies, international conferences and international organisations in industrialised countries for distribution among libraries in developing countries.

The ICTP also receives unused surplus scientific equipment from laboratories such as CERN, which it then ships to institutions in developing countries which have been selected by a scientist from the recipient laboratory.

3.6 The laboratories are the sixth component of the ICTP activities – the Microprocessor and the High Temperature Superconductivity. The Microprocessor Laboratory was created in 1985 and is jointly operated with the Istituto Nazionale di Fisica Nucleare (INFN), with the sponsorship of the United Nations University. It helps scientists from developing countries to get acquainted with microprocessor technology and to develop projects of their own which they will use in their home countries. It also provides technical support to other activities taking place at the ICTP or outside. The laboratory of high temperature superconductivity created in 1988 will be fully operational in 1989.

4.1 One of the reasons the Centre was created was to check the brain-drain which forced the best scientists from the developing countries to emigrate to the advanced nations where they would find a congenial atmosphere in which to carry out their research. Something had to be

invented to bring to an end the isolation of the scientists who had chosen to remain in their own countries – an isolation due to the lack of opportunities to interact with their colleagues or to attend international conferences, and the nearly total absence of scientific journals and books in their libraries. The response of the ICTP to this necessity was the creation in 1964 of the Associate Membership Scheme. Associate Members are scientists from and working in developing countries who are appointed for a period of six years, during which they are entitled to three research visits to the ICTP. Each visit should last at least six weeks but should not exceed three months. During their stay at the ICTP, Associate Members work either independently or in collaboration with other scientists in residence. Their travel and subsistence expenses are borne by the ICTP. In 1988, some 480 scientists from developing countries were Associate Members of the ICTP.

Certain former Associates who have acquired international reputation may be appointed as Senior Associates for six years.

For younger scientists, the ICTP has set up the Junior Associateship, a scheme which is mainly meant to help those working in institutions in developing countries with poor library facilities. Junior Associates are selected among participants in courses or workshops. During their four-year appointment they are entitled to order books through the ICTP or subscribe to scientific journals for their home libraries. In 1988, 148 scientists were Junior Associates.

4.2 In 1964, the ICTP developed a scheme for universities from neighbouring countries which would grant them regular access to its activities. This was the Federation Scheme. Again, this scheme proved to be the genuine response to a widespread need and gradually extended to more

distant countries. Up until 1989, the centre concluded some 380 federation agreements with research institutions mostly in developing countries. Federated institutions are entitled to send junior scientists to the ICTP for a total number of days which may vary from 40 to 120, depending on the geographical location of the Institution. The subsistence expenses of the visitor are borne by the ICTP, while, as a rule, the federated institution bears the cost of travel. The ICTP may, however, contribute partially to the travel costs.

5. The ICTP programmes are now carried out in several buildings located in Miramare. The main building – 3,000 sq. m – houses the library (35,000 books and 800 scientific periodicals), a 280-seat lecture hall, a 100-seat lecture room, offices for scientists and part of the secretariat, the computer facilities and a cafeteria. A new building, equal in size to the main one and adjoining it, is being complated and will be inaugurated in October 1989. It will provide more room for the library and two additional lecture rooms. A second building, named after Galileo Galilei, was the first guest house of the ICTP. It has 40 double bedrooms and a lecture room for 60 people.

To cope with the dramatic increase in its activities since 1983, the ICTP rents a hotel, now named the Adriatico Guest House, with 172 beds, two lecture halls and several meeting rooms as well as offices for scientists and the secretariat. The high-temperature superconductivity laboratory, the microcomputer facilities, part of the library collections and the printing shop are housed in this building.

The microprocessor laboratory is housed in a former elementary school rented to the Municipality of Trieste. All buildings are within walking distance of one another.

6. The ICTP draws its financial resources from the International Atomic Energy Agency (IAEA), the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and, mainly, from the Government of Italy for its regular activities. The Italian General Directorate for Co-operation to Development provides funding for special projects. In particular, it bears nearly all the costs of the programmes for training in Italian laboratories and of the external activities. The Swedish Agency for Research Co-operation with Developing Countries (SAREC) supports part of the associateship programme. Other contributions are received from the Arab Fund, Brazil, the Government of Japan, the Kuwait Foundation for the Advancement of Sciences, Qatar, the Royal Society (UK), the United Nations University and the National Academy of Sciences and Arts (USA). The annual budget of the ICTP is of the order of US$15 million.

7. In February 1988 Professor Abdus Salam proposed the creation of a new International Centre for Science (ICS) including Centres for High Technology and Material Sciences, for Pure and Applied Chemistry and for Earth and Environmental Sciences. Thanks to a special grant from the Government of Italy received through the United Nations Industrial Development Organisation (UNIDO), a feasibility study for this new endeavour was started in July 1988 with Counsellor G. Rosso Cicogna as its Project Leader. Steering Committees appointed for each centre have suggested pilot activities which will contribute to the definition of the long-term programme. These activities will start gradually in 1989. It is expected that the laboratories will be fully operational in 1991.

Since 1964, the ICTP has welcomed 36,000 scientific visitors, 20,000 of whom were from developing countries. Some 4,000 scientists come each

year. More than half of them are nationals from developing countries. In terms of participation expressed in man/months, 82% is used by the developing countries.

APPENDIX II

THE THIRD WORLD ACADEMY OF SCIENCES

M. H. A. Hassan

In October 1981, Abdus Salam proposed the creation of a Third World Academy of Sciences (TWAS) on the occasion of a general meeting of the Pontifical Academy of Sciences in Rome. Nine members of that Academy; C. Chagas (Brazil), H. Croxatto (Chile), J. Döbereiner (Brazil), M. G. K. Menon (India), T. R. Odhiambo (Kenya), C. Pavan (Brazil), M.. Roche (Venezuela), Abdus Salam (Pakistan) and S. Siddiqui (Pakistan), signed a declaration in support of the establishment of the new Academy.

The Third World Academy of Sciences was founded in 1983 and formally inaugurated in 1985 by the United Nations Secretary General, Mr. J. Perez de Cuellar, on the occasion of the opening of a Conference on South-South and South-North Co-operation in Sciences, which was attended by 250 delegates representing academies and research councils from the South and the North and representatives from international organisations.

TWAS presently has 165 members representing 46 Third World countries. Ten of them are Nobel Laureates of Third World origin and 89 are members of nine of the most prestigious academies.

The programmes of TWAS aim at:
(a) recognising and supporting scientific excellence and encouraging the

pursuit of science in the Third World through TWAS awards to individual scientists who have made outstanding contributions to the advancement of science and through financial assistance to academies and research councils for instituting prizes and medals to young scientists in their countries.

(b) supporting research projects and scientific infrastructure in the Third World through TWAS research grants, provision of spare parts for scientific equipment in the Third World countries, and provision of books and journals to Third World libraries;

(c) promoting South-South and South-North collaboration through South-South fellowships. Governments and scientific organisations in Argentina, Brazil, Chile, China, Colombia, Ghana, India, Iran, Kenya, Madagascar, Mexico, Vietnam and Zaire have so far agreed to provide local hospitality for a total of over 250 annual visits under the fellowship programme.

The Academy also promotes South-South and South-North collaboration through TWAS/ICTP Fellowships, the TWAS/CIPE (International Centre of Insect Physiology and Ecology in Nairobi, Kenya) Associateship Scheme, support for scientific meetings, fellowships in Italian laboratories in the fields of geological, biological and chemical sciences, ICSU/TWAS programmes of lectures, and a joint project initiated by the Academy, the African Academy of Sciences and the National Academy of Sciences of the USA regarding drought, desertification and food deficit in Africa. The project is currently supported by the Academy, the World Bank and the MacArthur Foundation.

In October 1988, the TWAS created a Third World Network of Scientific Organisations whose general objective is to promote South-South and South-North co-operation in the development of sciences and technology in the Third World. Over 100 scientific organisations in the Third World, including 24 Ministries of Science, Technology and Higher Education, have joined the Network as members. In particular, the Network will further the contribution of the South to global project of science (UNESCO's Man and the Biosphere and ICSU's International Geosphere Biosphere Programme); will further the contribution of the South to areas of today's frontier science and technology which are most likely to have a strong impact upon the economic and social development of the Third World; will promote and strengthen co-operation between academies, research councils and scientific organisations in the Third World and enhance their role in the development of the Third World, including information sharing through the setting-up of data banks; will further relations between scientific institutions and organisations in the South, and with their counterparts in the North through the development of bilateral links and exchange programmes; will encourage Third World Governments to take appropriate political action to develop their scientific enterprise through self-reliance and adequate allocation of resources; and will undertake any other activities that will further the objectives of the Network.

The activities of the Network are co-ordinated by an Executive Board and three committees.

The financial resources of the Academy are, at present, derived from the Italian Government (through the Direzione Generale per la Cooperazione allo Sviluppo), the Canadian International Development

Agency (CIDA), the Kuwait Foundation for the Advancement of Sciences (KFAS), the OPEC Fund for International Development, the Consiglio Nazionale delle Richerche (CNR), and the Government of Sri Lanka.

Governments and scientific organisations in 13 developing countries have agreed to provide financial support to cover local expenses for more than 250 visits to their countries under the South-South Fellowship programme in the Academy.

HOW THE NORTH SHOULD HELP THE SOUTH

1. Ten per cent of the total bilateral aid funds from the North should be earmarked for enhancing science and technology in the South.

2. The North should help the South in gaining access to scientific literature by, for example, making arrangements with publishers of the North to make scientific books and periodicals available to libraries in the South at a fraction of their present price or by donation.

3. The North should help the South in building up scientific infrastructure, assisting existing centres and creating new ones in the developing countries. In this context, there is a proposal to create in Trieste three new international centres, one for High Technology and New Materials, one for Earth Sciences and the Environment and one for Chemistry, Pure and Applied, in addition to the existing International Centre for Theoretical Physics and the International Centre for Genetic Engineering and Biotechnology.

Published by
EDINBURGH UNIVERSITY PRESS

on behalf of
THE CITY OF EDINBURGH DISTRICT COUNCIL

in association with
THE EDINBURGH INTERNATIONAL FESTIVAL OF SCIENCE AND TECHNOLOGY

Design contributed by
TAYBURN DESIGN GROUP
EDINBURGH

The Edinburgh International Festival of Science and Technology has been established as an annual international forum on the general theme of 'Science and Society'.

It takes place each Spring and comprises exhibitions, lectures, conferences, debates and seminars for scientists, technologists and the lay public together with the response to the sciences by the arts in music, film and drama.

For further information please contact the
Edinburgh International Festival
of Science and Technology,
County House, 20/22 Torphichen Street,
Edinburgh, Scotland, EH3 8JB,
telephone number 031-228 4756,
fax number 031-225 9613.

EDINBURGH UNIVERSITY PRESS
22 George Square, Edinburgh

ISBN 0 7486 0144 9